SUITABILITY STUDY OF RIPPER -DOZER COMBINATION IN INDIAN MINES

THESIS ACQUIESCED FOR FRACTIONAL FULFILLMENT OF THE NECESSITIES FOR THE DEGREE OF

BACHELOR IN TECHNOLOGY

INMINING ENGINEERING

GIVEN BY

MANISH SINGH

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DEPARTMENT OF MINING ENGINEERING

NATIONAL INSTITUTE OF TECHNOLGY

ROURKELA-769008

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ROURKELA

CERTIFICATE

This is here to certify that the thesis

TITLED AS "**SUITABILITY STUDY OF RIPPER DOZER COMBINATION IN INDIAN MINES"**

Is acquiesced by

Sri MANISH SINGH for

the partial contentment of the necessities for

the honour of Bachelor of Technology degree

in Mining Engineering at National Institute of Technology,

Rourkela (Deemed University) is a reliable work performed

by him under my observation and guidance.

To the best of my awareness,

the work provided in this thesis has not been acquiesced

to any other University/Institute for the honour of

any Degree or Diploma.

Professor-H.K.NAIK

Department of Mining Engineering

N.I.T Rourkela

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"Suitability study of ripper-dozer combination in Indian mines"

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..Assembly of work of this type could never have been tried and performed

in the lack of reference and motivation

from other's work whose details are stated in the

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MANISH SINGH

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CONTENTS

ABSTRACT

In the open cast mining drilling and blasting operations are required for extraction of ore or coal and simultaneously it helps in loosening the strata. Drilling and blasting operations are associated with a numerous number of problems such as formation of dust, evolution of harmful gases, ground vibrations, crack development and production of noise. As a result these operations are not considered as eco-friendly. So we are in a search of blast free mining method. Also these operations are too costly as a lot of machinery and labour cost is associated with it. Blast free mining is the demand of the era to conserve the environment. As s a result from various kinds of studies and research it has been found that Ripper dozer could be a possible solution. Ripper dominantly put in use for the extraction of overburden. It not only reduces the number of machinery but also produces a better solution for the problems posed by drilling and blasting operations. As a result we have to be conscious for installing any ripper and dozer so proper rippability measurement of the strata with the present machine to be installed must be done properly. There are various constraints on which rippability of rocks depend on. Relationships are studied between the constraints and production of rippers. Taking in account of all these constraints rippers are employed into the mines.

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CHAPTER 01

INTRODUCTION

1.1 LAYOUT:

From the various studies and researches it had been found that mining practices started way back from ancient times. Back to the history romans did hydraulic mining to fracture the rocks but it got pace when black powder was invented by the Chinese as the explosive in medieval period.

Also when this concept reached to Europe new technologies came into play. Then invention of dynamite increased the pace of mining in late middle period and the starting of modern period.

Now a days use of ammonium nitrate and various other explosives has in miracle increased the production .But proper use of drilling pattern and placement of holes with right amount of explosives provide the efficiency in breakage of rocks. Advancement in various techniques in blasting and drilling techniques were also associated with advancement in transporting and loading techniques in order to get higher production rates. At the present day's scenario we can think of mining up to more depth by open cast mining methods with such a revolution in the technologies. As a result we can observe that open cast mining holds 70% of world's total production in mining. Mining of ores by open cast method requires drilling and blasting operations as they give a heavy amount of production but as it is well known that these techniques have many opposing effects on environment. So in today's era of eco-conscious world the demand is there for alternatives technology for explosion free, harmless and eco-friendly mining. Ripper dozer combination can come as a strong and suitable answer as the modern requirements. It not only reduces the adverse effect but also reduces the cost of production by minimizing the operations of mining.

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1.2 Objective:

The sole objective is to study the applicability and performance of ripper-dozer combination and suggest some modern advancement in coal and metal opencast mines.

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1.3 Research Approach:

I. A heavy amount of literature study has been done in order to recognize the various constraints and there effect on the performance of ripper-dozer combination.

II. C++ programs are introduced to minimize the calculation and modernize the study technique.

III. Various Ripper dozer present in the market and there comparisons along with specification have been provided

IV. Two different case studies have been done to study the performance and applicability of ripper dozer. The case studies belong to *Panchpatmali mines (bauxite), N.A.L.C.O, Damanjodi* and *Talabira coal OCP, HINDALCO* have been studied.

V. Modern advancements also have been mentioned in this thesis.

CHAPTER 02

LITERATURE REVIEW

2.0 Contextual:

Ripping -dozer combination started in late 1950s .Earlier it was only use for removal of the overburden. But with developments in its structure now days it has been use for extraction of ores also. Ripping is done to cut, break, or loosen the rock with the help of tynes attached in the back side of the bulldozer. The Tyne is lowered into the rock or the soil to be extracted, it goes deep in the strata then the bulldozer is moved in forward direction in order to remove the soil or rock. It works with the same technique as the plough works. As compared to drilling and blasting operations ripping is commonly beneficial for comparatively soft rocks.With increased concern over the preservation of ecosystem by the whole world and implementation of various laws has driven for the solution such as ripper dozer combination. It not only reduces the air, noise and dust pollution but also abolishes the ground vibration which poses a serious threat on preserving surface features. With the reforms in science and technology by the use of high power and capacity ripper it has become possible to use as alternative for drilling and blasting practices. We can say that rippers came into the role in about 312 B.C as it uses the same technique used by ancient humans for plough driven by oxen in order to do cultivation. As the time passed a lot of developments were made and in present times we can see that we have rippers weighing up to 1000 tones and operating with a power of 1000 H.P tractor.

2.1 Advantages of ripping operation:

Increase in production and productivity: When we use ripper dozer combination the work is always going on. There is no need for drilling, charging the holes and afterwards performing blasting operations. Contrary to that in ripping process is uninterruptedly going on. This as a result reduces the idle time work. There is no need for shifting of machines which is required in blasting operation. So, as time of work increases the production and productivity also increases. **Extraction with required Size:** In blasting operation the size of extracted rock varies a lot it may range from boulder size to the size of a few mm. On the other hand we can get the desired size of rock by the selection of right size of the ripping machine.

Reduced power: with the reduction in machines the power required for operating them is also reduced.

Profitable: Ripping involves less amount of machinery so the cost is lowered as there is no cost for operation, labour and machine maintenance.

Monitoring the quality of ore: In blasting, operation, the ore can be diluted. But, in ripping process the operator can easily differentiate between ore and waste.

Reduction in noise and dust pollution: In ripping operation comparatively less amount of nose is produced. It reduces the dust quantity and prevents them from becoming airborne.

Reduced level of ground vibration: Drilling and blasting operation gives a heavy amount ground vibration by which a lot of adverse effects are caused such as creation of cracks on ground and nearby structures which is not observed in drilling and blasting operation.

Eco-friendly Mining: As the amount of production of pollution is reduced at a very high level so we can say that it is solution as eco-friendly mining.

Selective Mining: We can perform selective mining as the operator can easily differentiate between ore and the waste rock. Also where water bodies are nearby we can use it as we can easily extract the right amount of ore without any disturbance.

Stability of slope: Unlike the ripping technique in blasting operation slope failure is often observed .

Safety: There are chances of flying rocks and misfire which may endanger the life but no such thing is observed in ripping operation.

2.2 The different kinds of Rippers available: (P. K Panda and S. K Misra , 1989)

The different kind of ripper and dozer available in market classified according to methodology of working are as follows:

Hinge kind of ripper

Parallelogram kind of ripper

Adjustable parallelogram kind of ripper

Adjustable radial kind of ripper

1) **Hinge kind of ripper:**

Ripper of this kind has a assembly holding the beam and the bar hinges at the hindmost end of the ripper. It utilizes a beam by one or more pockets to hold one to five bars. Each pocket allows up to five diverse bar locations to bend penetration and tooth angle to fulfil different condition. Hinge type offers the benefit of hostile tooth entrance angle but cannot be accustomed for changing rock conditions.

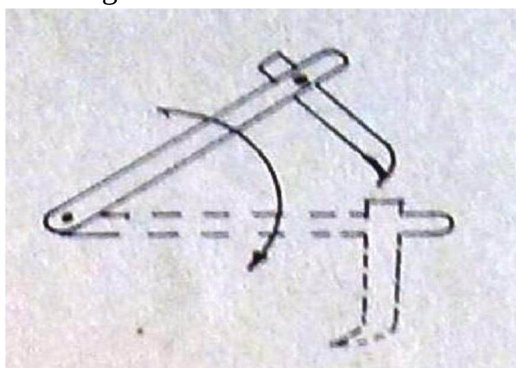


Fig.2.1 Hinge kind of ripper (P .K Panda and S. K Misra, 1989)

2) Parallelogram kind of ripper:

In the ripper of this kind the connection retains the identical tip ground angle irrespective of tooth complexity, therefore it possesses excellent penetration features. Single bar rippers are utilised specifically for firm ripping where larger ripping depth is required. The allowance between the pathways and the bars is more in case of parallelogram kind than hinge kind of ripper. The ripper is in elevated position which benefits the machinist to observe the tip damage or loss as a result it avoids the damage to the bar from ripping.

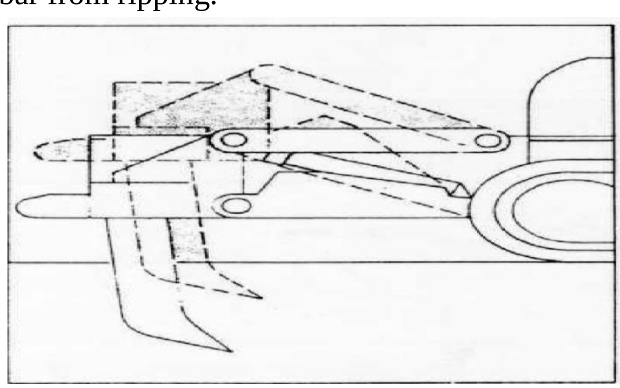


Fig. 2.2: Parallelogram type ripper

3) Adjustable parallelogram kind of ripper:

This kind of ripper has combined features of ripper of bot kind i.e. hinge type and parallelogram type. It facilitates angle variation for increased penetration and possesses hydraulically adjusting facility while ripping to deliver the finest ripping angle.

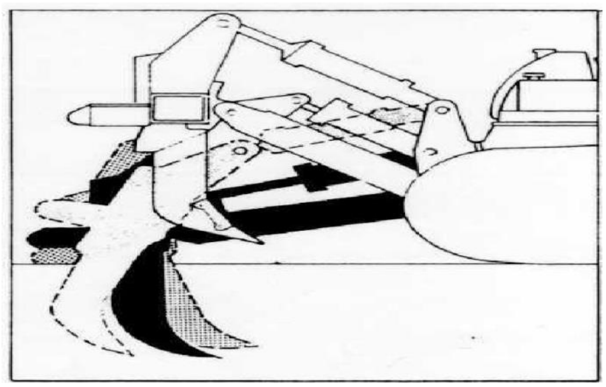


Fig. 2.3 Adjustable parallelogram type

4) Adjustable radial kind of ripper:

In the association with the features of hinge type it have the bar angles in elevation angles. It offers more violent bar penetration angle at jerk and finest angle for movement through the material.

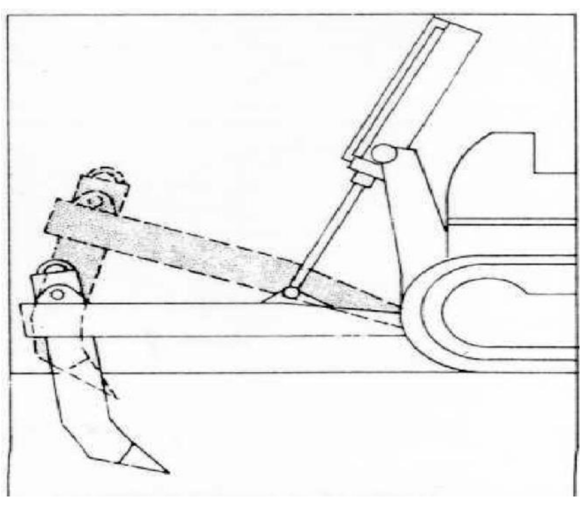


Fig.2.4: Adjustable radial type.

2.2 Calculation for rippability of a rock

To select the appropriate ripper first of all we should know the rippability of the rock. According to various researchers the rippability of rock depends on various factors. In the table given below it has been given that which parameter is given by which researcher.

FACTORS / RESEARCHERS	Field Seismic Velocity (m/s)	Fracture Index	Point Load Index	Rock Hardness	Rock Weatheribility	Joint spacing	Joint continuity	Joint gauge	Dip and Strike Orientation
Atkinson (1971)	yes	no	no	no	no	no	no	no	no
J.M.Weaver (1975)	yes	no	no	yes	yes	yes	yes	yes	yes
Kristen (1982)	yes	no	no	no	yes	yes	no	yes	no
Singh R N, Denby B and Egretli I (1987)	yes	no	no	no	yes	no	no	no	no
Hardy J Smith (1986)	no	no	no	yes	yes	yes	yes	yes	√ yes
Franklin, Broch and Walton (1971)	no	yes	yes	no	no	no	no	no	no

Table 2.1: Consideration of various different parameters by different researchers

Factors on which the extent of rippability of rock depends on are as follows:

- Type of rock to be ripped: Sedimentary rock is easy for ripping while Igneous & metamorphic rocks are difficult to rip..
- Fragility and crystalline construction of rock.
- Well-known fracture plane.
- Existence of Moisture content:
- More the Grain size: coarser the grain-size more it is suitable for ripping.
- Union of different type of rock.
- Specific energy.
- Various physical properties of strata such as compressive strength tensile strength, shear strength etc.

Fig.2.5: Type of extraction of rock on the basis of strata condition.

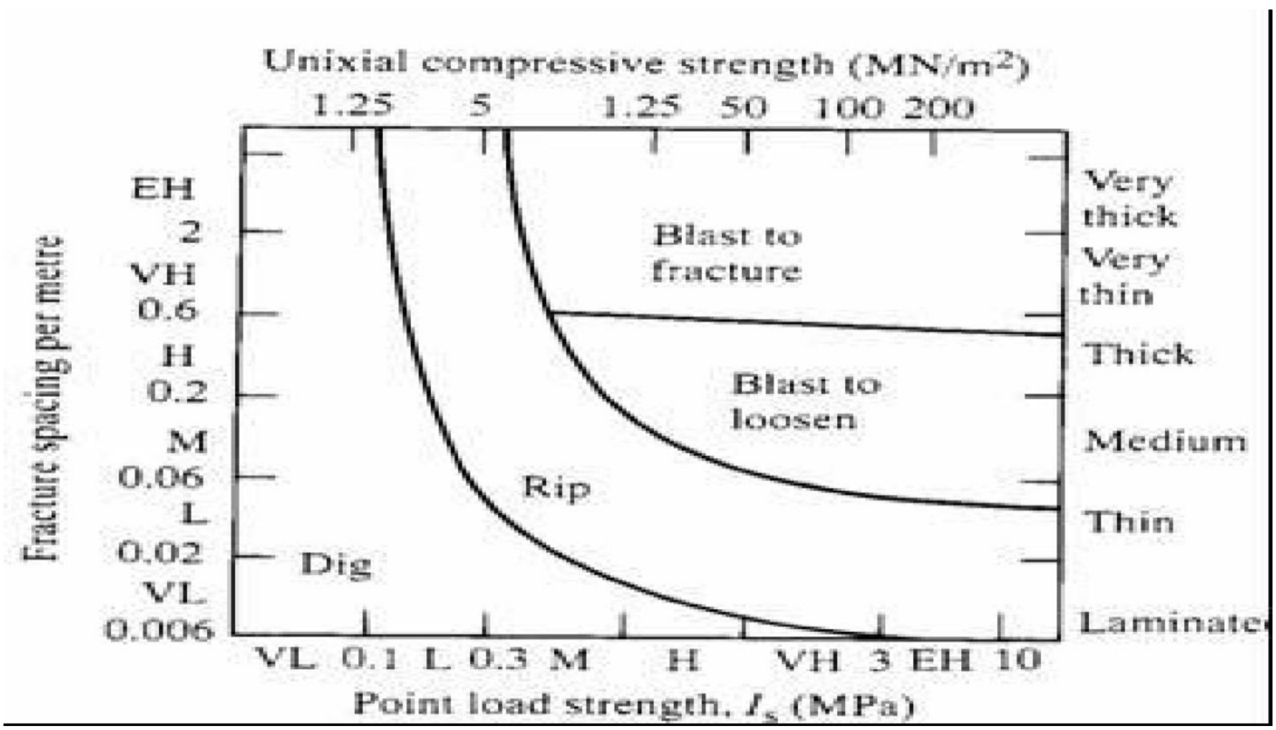


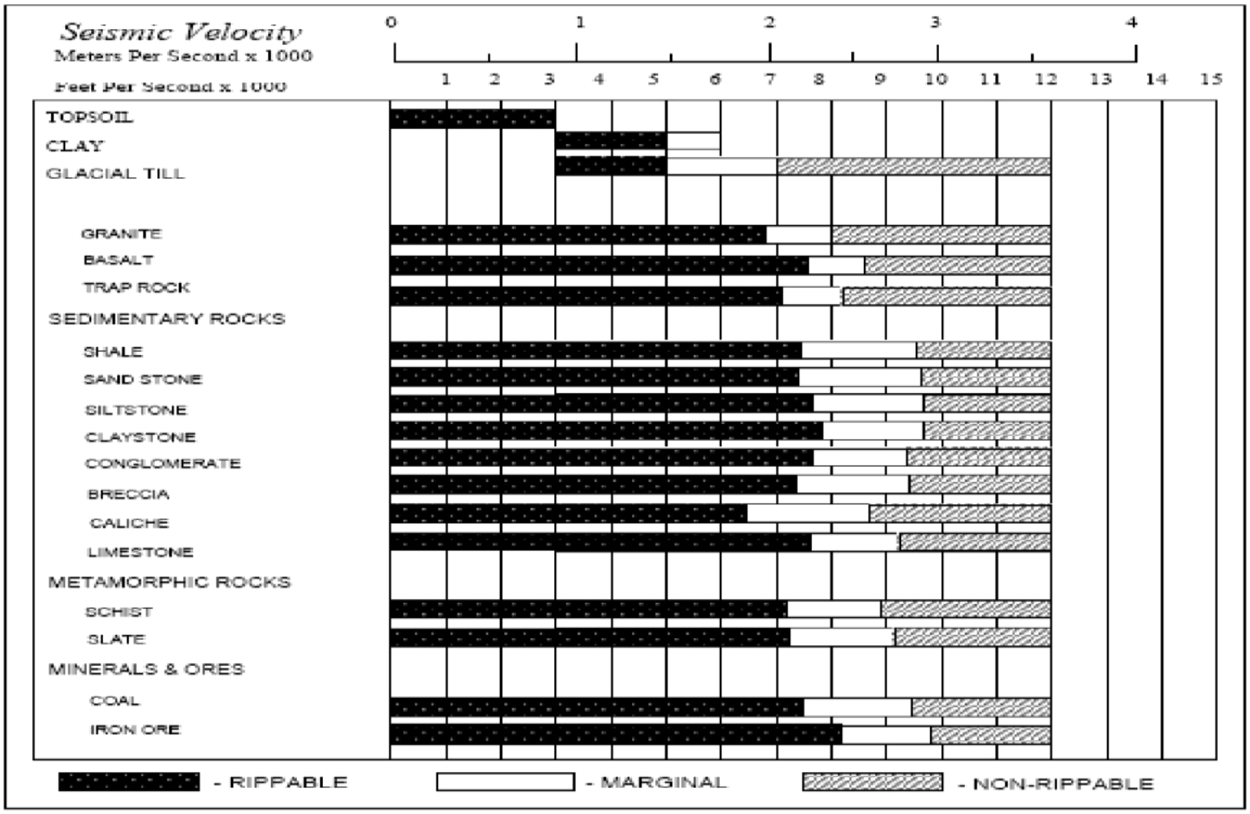
Table 2.2: Extent of ripping, taking various characteristics in account, (*Rock excavation techniques, MnE-415 notes, university of Arizuana mining and geological engineering.*)

Rock hardness description	*Identification criteria*	*Unconfined compression strength* (MPa)	*Seismic wave velocity* (m/s)	*Excavation characteristics*
Very soft rock	Material crumbles under firm blows with sharp end of geological pick; can be peeled with a knife; too hard to cut a triaxial sample by hand. SPT will refuse. Pieces up to 3 cm thick can be broken by finger pressure.	1.7–3.0	450–1200	Easy ripping
Soft rock	Can just be scraped with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of the pick point; has dull sound under hammer.	3.0–10.0	1200–1500	Hard ripping
Hard rock	Cannot be scraped with a knife; hand specimen can be broken with pick with a single firm blow; rock rings under hammer.	10.0–20.0	1500–1850	Very hard ripping
Very hard rock	Hand specimen breaks with pick after more than one blow; rock rings under hammer.	20.0–70.0	1850–2150	Extremely hard ripping or blasting
Extremely hard rock	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.	>70.0	>2150	Blasting

Table 2.3: Rippability of rock on the basis of joint spacing ,(*Rock excavation techniques, MnE-415 course notes, university of Arizona mining and geological engineering*.)

Joint spacing description	*Spacing of joints (mm)*	*Rock mass grading*	*Excavation characteristics*
Very close	<50	Crushed/shattered	Easy ripping
Close	50–300	Fractured	Hard ripping
Moderately close	300–1000	Block/seamy	Very hard ripping
Wide	1000–3000	Massive	Extremely hard ripping and blasting
Very wide	>3000	Solid/sound	Blasting

Fig.2.6: Relationship for seismic velocity and ripping conditions to ripping (*Basis: Caterpillar, 2008*).



2.3 Estimation for rippability of rocks

There are two methods by which Rippability can be found.

Direct method

Indirect method

2.3.1 Direct method:

In this method hourly production of the ripper is calculated from the site of field only . Hourly production rate (Q_h) is given in m^3/hr., which is either determined by volume by weight, volume by cross sectioning, and volume by length method (Basarir and Karpuz (2004)).

Hourly production rate, $\mathbf{Q_h = Q_c \times 60 \times E / t}$

Where, Q_C – Total volume of production in a complete cycle in (m3)

E – Operator's efficiency

t – Cycle time, minutes

Now, production in one cycle is given by, $\mathbf{Q_C = (A \times L)}$

Where, Q_C – Per cycle production in m^3

A – Cross sectional area, m^2

L – Ripping length, m

Cross sectional area is calculated by using following triangular cut.

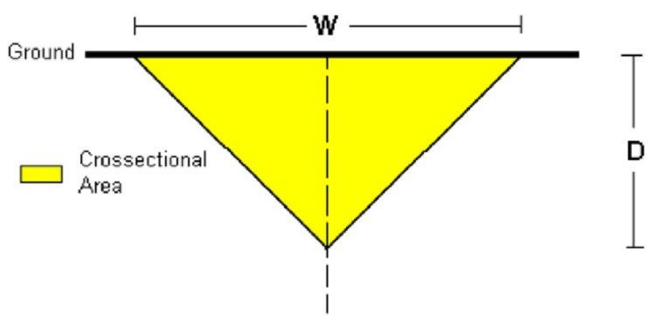


Fig.2.7: Triangular cross section cut

Cross sectional area,

$$\mathbf{A = DW/2}$$

Where, D – ripping depth, m

W – ripping width, m

Replacing the values mentioned above we can get hourly production.

2.3.2 Indirect method:

There are two indirect methods that are:

1. **Seismic**
2. **Laboratory**

We record the value of seismic wave velocity in the unit m/s and with the help of tests the following parameters could be known

a. Deepness of unconsolidated cover for example clay rock or gravel.
b. Wideness of the middle layers supposing each becomes gradually harder
c. Rough density of every layer and degree of association leading to identification of material type
d. Position of faults, fold, joint, fractures and other disturbances in the founding

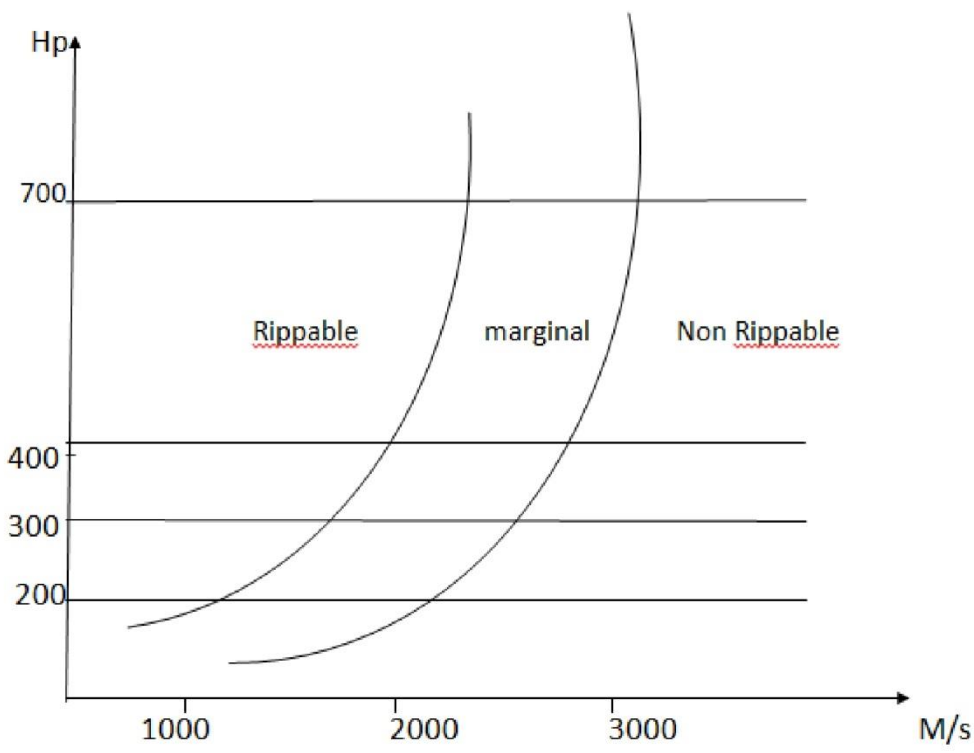
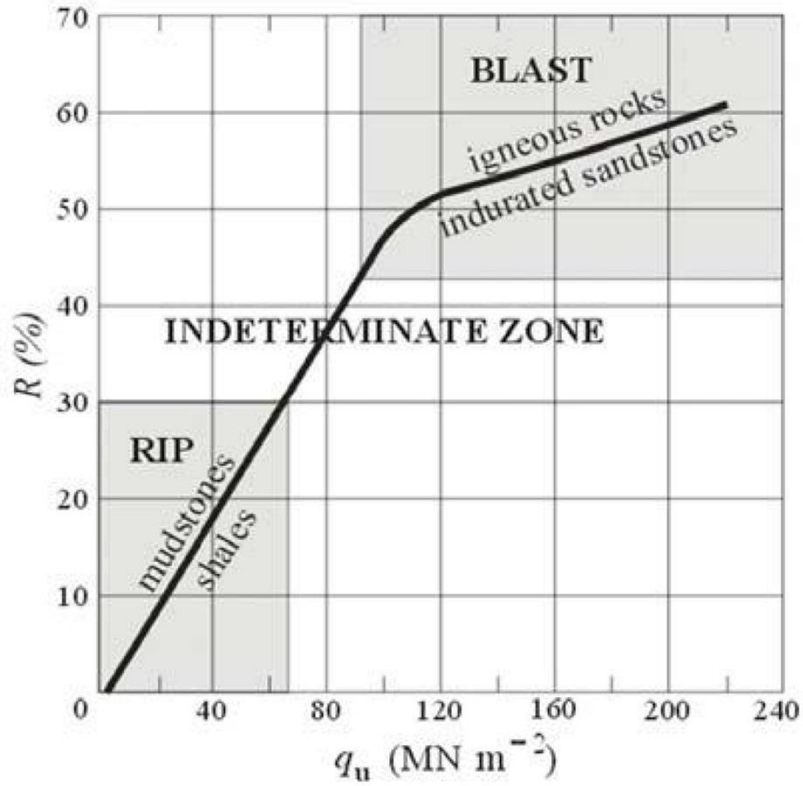


Fig.2.8: Ripping capacities (in term of power and seismic velocity)

Also on the basis of rock rebound number found by seismic study and its plotting with compressive strength we can find out the rippability of the rock



Source (*McLean & Gribble, 1985)*

Fig.2.9: Exclavability based on Rebound no.(R) and compressive strength(q_u)

2.3.3 Test done in laboratory:

In the laboratory various tests are done to find out various properties of rock mass such as universal compressive strength (UCS), indirect tensile strength (ITS) and point load strength index tests (I_{s50}).

Test done in the laboratory for ripping operations is performed by the machine shown below.

The machine simulates functioning of a single bar ripper with rating 1850 rpm, and cutting speed of 150m/s .

Particularly constructed cutting bar is used to create a V-cut in rock samples. Power calculated is noted by the readings. As a result we get specific energy in/m^3. With the help of the length of the cut (L) in meters, density of material produced, and volume of the material cut in m^3 is calculated.

In view of force (F) calculated in Mega Newton (MN)

Specific energy (SE) is given by,

$$\mathbf{SE = FL/V}$$

Fig 2.10: Machine use in laboratory to determine rippability.

The specific energies can be related to various rock parameters as shown in the table 2.4

Table 2.4: The association between specific energy and various rock properties (*H Basarir (2008)*)

The relationships between rock properties and specific energy

Parameter	Equation	R^2
Uniaxial compressive strength (UCS), MPa	$SE = 0.20UCS + 2.41$	0.81
Indirect tensile strength (UTS), MPa	$SE = 0.77ITS + 3.89$	0.85
Point load strength ($I_{s(50)}$), MPa	$SE = 4.58I_{s(50)} + 3.24$	0.88
Seismic velocity P-wave velocity (SV), m/s	$SE = 0.003SV - 0.052$	0.85
Schmidt hammer hardness value (SHV)	$SE = 0.17SHV + 0.076$	0.79

With the help of specific energy we can determine the hourly production of ripper by the findings shown in the graph given below.

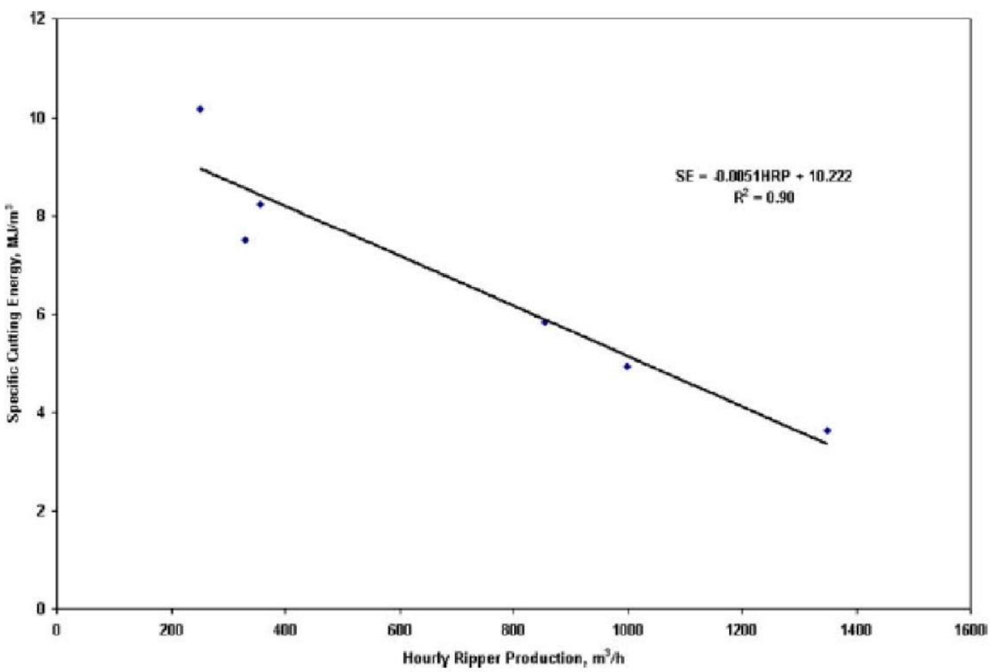


Fig.2.11: Dependence of specific energy and hourly production of ripper (*H Basarir (2008)*)

2.4 Working of the ripping machine:

Firstly the ripper tip is pull down in to the ground by help of hydraulic forces. The first penetration of the tip or Tyne is done by rock mass or fault planes or combination of both which is stated below in the figure.

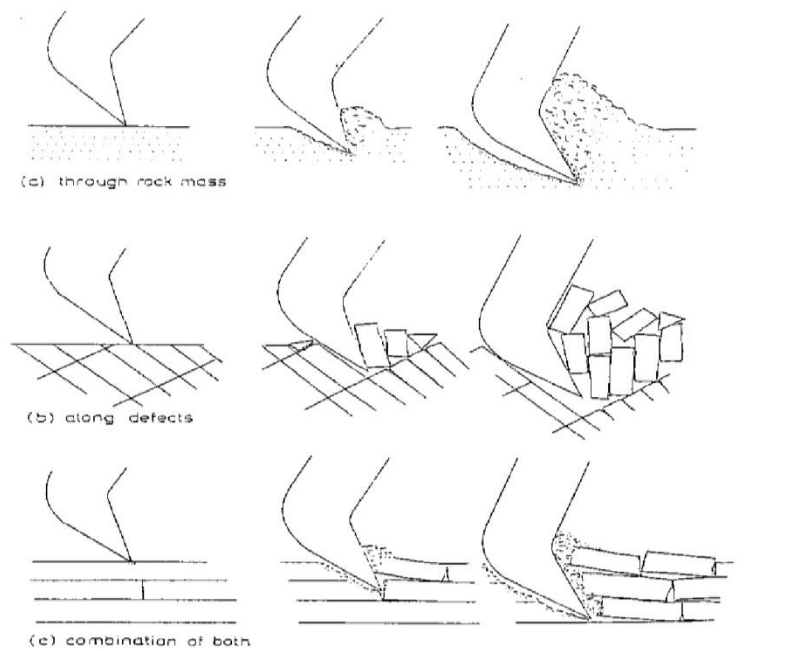


Fig.2.12 First penetration of Tyne with the help of hydraulic forces

As the stress deliberation of tip surpasses the compressive strength of the rock it accounts for shear failure of rock permitting first tip penetration. So when the tractor moves in the forward direction the penetration causes tensile failure of rock. Places where the jointed rocks occurs the failure takes place due to failure of cohesive force between the structural blocks.

2.5 RIPPING MECHANISM

Various ripping mechanism provided by ***Darcy, 1971***:

Ploughing: In compact rock in absence of bedding planes, a thin road is ploughed shifting very less amount of rock

.**Crushing:** It is done where the occurrence of fractured rocks having less defect spacing (0.1-0.3m) is observed. The material is easily rumpled and disorganized.

Lifting: It is done where straight stratified rocks is found, blocks are raised by ripper resulting the breakage by pull, twisting and cutting.

Breaking: It is done in the case of inclined stratified rocks by cutting at the point of the ripper by twisting and lateral pull.

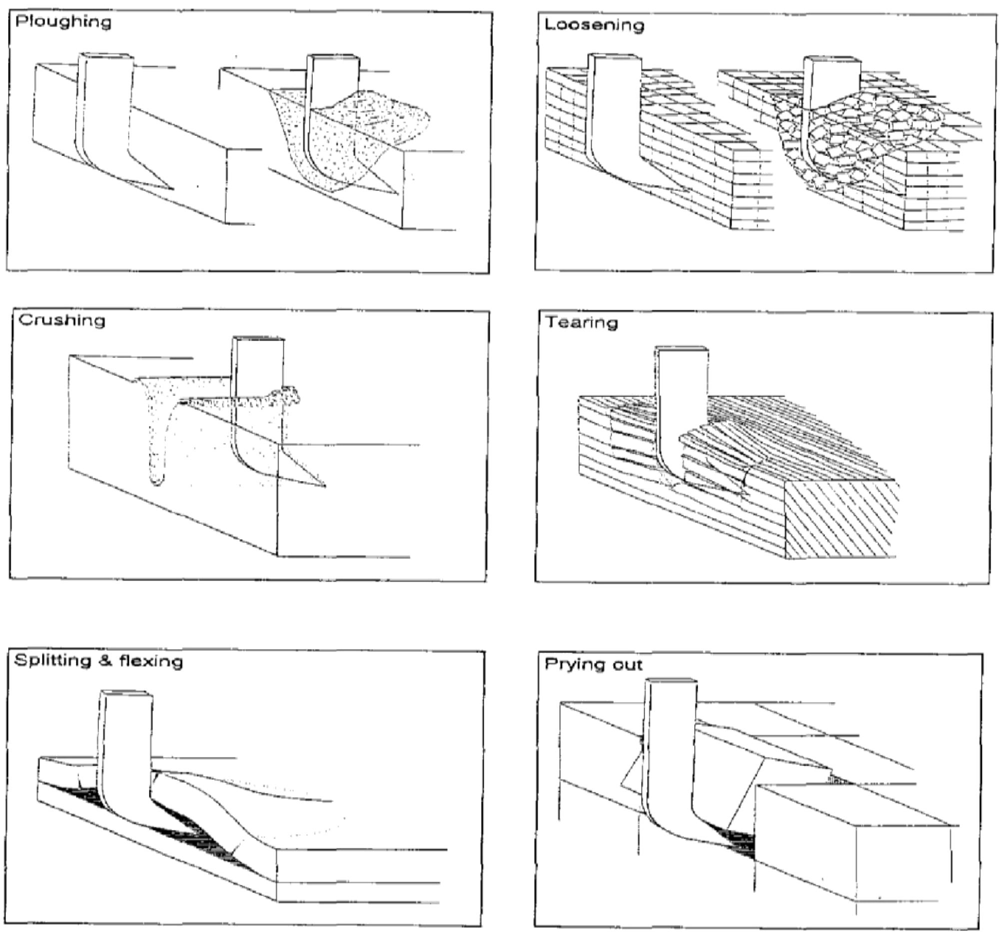


Fig 2.13 Ripping Mechanism

2.6 Attachment of the dozer blade or pusher blade with the ripper:

Ripper is employed with a dozer blade or pusher blade attachment. The dozer blade or the pusher blade can be elevated or dropped through small angles horizontally with the help of rams run by hydraulic pressure or ropes. The dozer blade or pusher blade is used to push materials ripped. A dozer can dig up to 1.5m underneath the ground in earth or weathered rock.

Commonly used different types of dozer:

Straight dozer: The straight blade contains of mould board angled forward and concave in the front. It comprises of removable cutting edge at the end. The straight blade has higher competence of improved penetration and handling of heavier material.

Universal dozer: It consists of blade which has big wings on either side of vital section. It is right for larger loads strapped over long distances. Wings are there to avoid the leakage of materials.

Semi-universal dozer: The semi-universal possesses the combined features of the above two. It consists of short wings. Universal blade is meant for larger loads pushed over long distances.

Output of dozer:

The output of the dozer can be calculated as:

$$\mathbf{Q = 60Cs\mu/t}$$

Where, Q- output in m^3/h

C – Dozer blade capacity

s – Swell factor

μ - production efficiency

t – Cycle efficiency

CHAPTER 03

3 C++ PROGRAMS FOR VARIOUUS CALCULATIONS

3.1Program to calculate hourly production rate

```
# include<iostream.h>
# include<conio.h>v
void main ( )
{
clrscr ( );
float l, d, w, A, Qc, Qh, E, t;
cout << “Press on the keyboard the length of cut (in m)”;
cin >> l;
cout << “Press on the keyboard   the width of cut (in m)”;
cin >> w;
cout << “Press on the keyboard   the depth of cut (in m)”;
cin >> d;
A= (w*d)/2;
Qc = (A*l);
cout << “Press on the keyboard   the operator’s efficiency’’;
cin >> E;
cout << “Press on the keyboard the cycle time in minutes’’;
cin >> t ;
Qh = (Qc * 60 * E)/t ;
cout << “The hourly production rate in m3 / hr.’’ << Qh ;
```

```
getch ( ) ;}
```

3.2<u>**Program for calculation of specific energy in laboratory**</u>

```
# include<iostream.h>

# include<conio.h>

void main ( )

{

clrscr( );

float l, f, v, SE;

cout << "Press on the keyboard the length of sample (in m )";

cin >> l;

cout << "Press on the keyboard the volume of sample (in m3)";

cin >> v;

cout << "Press on the keyboard the force acting on sample in Mega Newton'';

cin >> f;

SE = (f*l)/v;

cout << "Specific energy in M.J/m '' << "is'' << SE;

getch ( );

}
```

3.3Program to calculate output of a dozer

```
# include<iostream.h>

# include<conio.h>

void main( )

{

clrscr ( );

float Q, C, s. µ, t;

cout <<  "Press on the keyboard the dozer blade capacity in m ";

cin>> C;

cout<< "Press on the keyboard to give value for swell factor";

cin>> s;

cout << "Press on the keyboard the - production efficiency";

cin >> µ;

cout << "Press on the keyboard the  cycle time";

cin >> t;

Q = (60*C*s*µ)/ t;

cout << " The output of dozer is" << Q ;

getch (  ) ;

}
```

CHAPTER 04

SPECIFICATION OF VARIOUS RIPPER- DOZER AND THERE APPLICABILITY

Table 4.1 Specification of various ripper dozer available in India by different manufacturers

	CATEERPILLAR D8R	KOMATSU D155A-6	CATERPILLAR D9R	KOMATSU D275A-5	KOMATSU D375A-6	KOMATSU D475 A-5	BEML BD475	CATERPILLAR D10R	CATERPILLAR D11T
ENGINE									
Manufacturer	CATERPILLAR	KOMATSU	CATERPILLAR	KOMATSU	KOMATSU	KOMATSU	CUMMINS	CATERPILLAR	CATERPILLAR
REFERENCE	AEHQ6045	CEN0003-02	AEHQ5593	CEN00228-02					
Type	HEUI	CRDI	HEUI	CRDI	CRDI	CRDI		MEUI	ADEM
Model	3406C	SAA6D140E-5	CAT3408C	SAA6D140E-5	SAA60170E-5	SAA12V140E-3	VTA-28C	CAT C27	CAT C32
Gross Power SAE JI995	328 HP	360HP	474 HP	452HP	636 HP	899 HP	NA	646 HP	932 HP
Net Power SAE J1349	302 HP	354HP	401 HP	449HP	610 HP	890 HP	770 HP	580HP	850 HP
Rated rpm	2100	1900	1900	2000	1800	1900	2000	1800	1800
Displacement (L)	14.6	15.24	18	15.24	23.15 L	30.48	28 L	27 L	32.1 L
No. of cylinders	6	6	6	6	6	12	12	6	12
Bore X Stroke(	137 mm X 165 mm	140 mm X 165 mm	137mm X 152 mm	140 mm X 165 mm	170 mm X170 mm	140 mmX 165 mm	140 mmX 152 mm	137.2mm X 152.4 mm	145 mm X 162 mm
Aspiration	Turbocharged and aftercooled	Turbocharged, air to air aftercooler and EGR	Turbocharged and aftercooled	Turbocharged, air to air aftercooler and EGR	Turbocharged, air to air aftercooler and EGR	Turbocharged, air to air aftercooler	Turbo charger with after cooler	Turbocharged, air to air aftercooler	Turbocharged, air to air aftercooler
OPERATIONAL									
Operating weight(including SU Blade and Ripper)	37771KG	41700 KG	48784 KG	50850 KG	71640 KG	108390 KG	95340 KG	67302KG	112698 KG
Fuel tank Capacity	625L	625L	908.4 L	840 L	1200 L	1670 L	1520 L	1204 L	1609 L
Cooling system fluid capacity	92 L	82L	129.8 L	100 L	120 L	275 L	215 L	151L	269 L
Engine oil capacity	32.5 L	37 L	45.5 L	52 L	86L	121 L	55 L	76 L	103 L
Hydraulic oil capacity	72 L	85 L , RIPPER(MULTI SHANK & GIANT) - 37L	77 L	130 L, RIPPER (MULTI SHANK AND GIANT)- 38 L	130 L, RIPPER(MULTI SDHANK & GIANT)- 45L	180 L, RIPPER (MULTI SHANK & GIANT) -130 L	180 L , RIPPER - 130	144 L	223 L
Powwer train oil capacity	144 L	90 L	164 L	90 L	150 L	210 L	210 L	193 L	344 L
Final Drive oil capacity (each side)	14 L	31L	15 L	40 L	65 L	75 L	75 L	23 L	47L
Operational voltage	24 V	24V	24 V	24 V	24 V	24 V	24 V	24 V	24 V

TRANSMISSION									
TYPE	POWERSHIFT	TORQFLOW	POWERSHIFT	TORQFLOW	TORQFLOW	TORQFLOW		POWERSHIFT	POWERSHIFT
No. of forward speed	3	3	3	3	4	3	3	3	3
No. of reverse speed	3	3	3	3	4	3	3	3	3
Max forward speed	10.8 KM/HR	11.4KM/HR	11.9 KM/HR	11.2 KM/HR	11.8 KM/HR	11.2 KM/HR	10.9 KM/HR	12.7 KM/HR	11.8 KM/HR
Max reverse speed	13.8KM/HR	13.7KM/HR	14.7 KM/HR	14.9 KM/HR	15.8 KM/HR	14 KM/HR	14.3 KM/HR	15.8 KM/HR	14 KM/HR
UNDERCARRIAGE									
Ground Pressure	92.8KPA	115.8 KPA	112.88 KPA	117 KPA	145 KPA	166 KPA	116.7 KPA	140.55 KPA	175.30 KPA
Ground contact area	3.6 sqm	3.52 sqm	4.24 sqm	4.2465 sqm	4.8 56sqm	6.4 sq.m	5.943 sq.m	4.7 sq.m	6.3 sq.m
Standard shoe size	560 mm	560 mm	610 mm	610 mm	610 mm	710 mm	710 mm	610 mm	710 mm
No. of shoes per side	44	41	43	39	41	41	39	44	41
No. of carrier rollers per side	2	2	2	2	2	2	2	1	1
No. of track rollers per side	8	7	8	7	8	8	8	8	8
Track pitch	216 mm	na	240 mm	na	na	na		260 mm	318 mm
Track gauge	2082 mm	2140 mm	2250 mm	2260mm	2500 mm	2770 mm	2770 mm	2550 mm	2896 mm
HYDRAULIC SYSTEM									
Type	CLSS	CLSS	CLSS	CLSS	CLSS	CLSS	CLSS	CLSS	CLSS
Pump type	piston type	piston type	piston type	piston type	variable piston	variable piston	Gear pump	Gear pump	Gear pump
Pump flow capacity at rated rpm	239 L/min	200 L/min	235 L/min	230 L /min	366 L/min	na	585 L/min	516 l/min	620 L/min
Relief valve pressure	24.1 MPA	27.5 MPA	26.2 MPA	27.5 MPA	27.5 MPA	27.5 MPA	20.6 MPA	20.3 MPA	24.3 MPA

BLADE SPECIFICATIONS									
SEMI U TYPE									
Height	1690mm	1790mm	1934 mm	1960 mm	2265 mm	2690 mm	2610 mm	2120 mm	2753mm
Width	3937mm	4130mm	4310 mm	4300 mm	4635 mm	5265 mm	5265 mm	5260 mm	5580 mm
Capacity	8.7 cu.m	9.4 cu.m	13.5 cu.m	13.7 cu.m	18.5 cu.m	27.2 cu.m	25.6 cu.m	18.5 cu.m	27.2 cu.m
Maximum Tilt	951mm	950 mm	940 mm	1000 mm	1185 mm	770 mm	1250 mm	993 mm	1184 mm
Max lift above ground	1231mm	1250mm	1422 mm	1450 mm	1690 mm	1620 mm	1620 mm	1497 mm	1533 mm
Max Digging depth	582mm	590mm	606 mm	640 mm	735 mm	1010 mm	800 mm	674 mm	766 mm
FUL U TYPE									
Height	1740mm	1790mm	1934 mm	1973 mm	2265 mm	2610 mm	2610 mm	2120 mm	2828 mm
Width	4262mm	4130mm	4650 mm	4615 mm	5140 mm	6205 mm	6205 mm	5260 mm	6335 mm
Capacity	11.7 cu.m	11.9 cu.m	16.4 cu.m	16.6 cu.m	22 cu.m	34.4 cu.m	34.4 cu.m	22 cu.m	34.4 cu.m
Maximum Tilt	1028 mm	970 mm	1014 mm	1070 mm	1300 mm	905 mm	1475 mm	1074 mm	1344 mm
Max lift above ground	1231mm	1250mm	1422 mm	1450 mm	1690 mm	1620 mm	1620 mm	1497 mm	1533 mm
Max Digging depth	582mm	590mm	606 mm	640 mm	735 mm	1010mm	800 mm	674 mm	766 mm
DIMENSIONS									
Length of machine with blade and single shank ripper	7917mm	8680mm	8138 mm	9290 mm	10485 mm	11565 mm		9158 mm	10525 mm
Width over tracks	2642mm	na	2860 mm	na	na	na	na	3292 mm	3782 mm
Height from tip of grousers	3509mm	3510mm	3996 mm	3990mm	4285mm	4646 mm		4505 mm	4490 mm
Length of tracks on ground	3150mm	3206mm	3474mm	3480mm	3980 mm	4524 mm		3872 mm	4444 mm
Ground clearance	528mm	500mm	591mm	507mm	610 mm	655 mm		664 mm	675 mm
Min turning radius		2.14 m		3.9m	4.2 M	4.6 M	4.6 M		na

Ripping is dependent on a lot of factors but for the production amount to ease of ripping have also a relationship which is given below:

Table 4.2: Relationship between ease of ripping and production (*by Fiona MacGregor)*

PRODUCTIVITY (m^3/hr)	EASE OF RIPPING
0 - 250	Very difficult
250 - 750	Difficult
750 - 1500	Medium
1500 - 3000	Easy
3000 - 7000	Very easy

Dependence of specific energies and production for different types of Caterpillar ripper dozers.

Table 4.3 Extended rippability classes of marls (*by H. Basarir & C. Karpuz, 2004*)

Class	Grade	Specific	D8	Dozer	D9	Dozer	D10	Dozer	D11	Dozer
	Grade	Energy	Production, m^3/h	Assessed class	Production, m^3/h	Assessed class	Production, m^3/h	Assessed class	Production, m^3/h	Assessed class
1	0–20	<3.75	>1300	Very easy	>1500	Very easy[a]	>6000	Very easy[a]	>10000	Very easy[a]
2	20–55	3.75–5.25	900–1300	Easy	1000–1500	Easy	4300–6000	Very easy[a]	7000–10000	Very easy[a]
3	55–70	5.25–7.00	400–900	Moderate	450–1000	Moderate	1900–4300	Very easy[a]	3000–7000	Very easy[a]
4	70–85	7.00–9.00	250–400	Difficult	285–450	Difficult	1200–1900	Easy	2000–3000	Very easy[a]
5	85–95	>9.00	<250	Very difficult[b]	<285	Very difficult[b]	<600	Difficult	<800	Easy
6	95–100	–	0	Blast	0	Blast	<150	Very difficult[b]	<250	Difficult

[a] For these cases, there is point in using D10 or D11 type dozer, since even D8 type dozer will work in these site with high efficiency.
[b] In these sites, there in no need to use D8, D9 or D10 type dozers, since both type will results in too low production.

CHAPTER 05

5.1 FIELD STUDY 1: PACHPATMALI BAUXITE MINES, N.A.L.C.O

5.1.1 Introduction:

Panchpatmali bauxite mine is governed by National Aluminum Company Limited (N.A.L.C.O) accounts for production of 4.8 Million tons of bauxite ore in addition with 1.6 Million tons of over burden. Great size of rippers has been selected an alternative to drilling and blasting. Deposit found here are of Precambrian age. Overburden comprises of hard ferruginous laterite with a ranging of thickness from 0 to 3.5 m. accompanying with a layer spreading in thickness from 10 to 35m with an average thickness of 14m. Study of seismic wave velocity of different formation conducted by NGRI Hyderabad tells that it ranges from 1100m/s to 2600 m/s and more than80% of deposit falls within the velocity range of 1100 -1300 m/s and later 15% of the deposit falls inside the range of 1300 to 2600m/s and above.

It shows the amenability of the deposit for efficient and economic application of production ripping and enabled the engineers to select out of the existing rippers appropriate equipment for the various sizes of rocks.

Khondalites and Chanockite types of rocks are observed with granet, sillimanite Corundum feldspar quartz and also opaque ore minerals limonite and graphite as the major mineral constitutes.

Modest relief by means of slopes generally less than 10% although steeper over 2/5 of the deposit and very irregular contact between ore and bottom.

5.1.2 Technique of mining

Mining is done simultaneously in three different phases:

Excavation of overburden: Overburden comprises of top soil and laterite and is mined in two stages. Top soil is directly excavated and loaded will ahead of laterite & kept separately for using in plantation in reclaimed area. Total amount of laterite is mined in one bench only above bauxite maintaining a lead of 75m. Low quantity of overburden compared to ore & the relative softness of the rock allows breakage of the rock by ripping. Ripping is associated with blasting for the harder formation of rock. After blasting or ripping the OB is handled wheel loader & dozer to clean the mineralized top. Overburden is then loaded on 50/55 ton dumper with the help of loader. Afterwards it is sent to area where overburden is required for the reclamation.

Excavation of bauxite: The bauxite mining at present is carried out in two stages top bench mining & Bottom bauxite mining. The top benches are excavated by drilling & blasting with average bench height of 8 m. and the diameter of the drill holes are 150 mm which are drilled by DTH drill Charging is done with indo–boost , indo-gel & blasted to loosen the ore. The blasted mineral is loaded by the 8.7 m3 wheel loader into 50/55 ton dumpers which carry it to the crusher. The last bench of bauxite is mined selectively by using back hoe for whole bauxite extraction. Crushing of bauxite ore is done with the help of double roll toothed crusher up to a size of 150 mm and then its transportation is done. It is send to recycling plant with the help of belt conveyor which is 14.6 km long

Reclamation for the removed area: Reclamation is simultaneously done as the adopted mining method used is trench mining method. When complete bauxite extraction is completed the area is set free for back filling with the help of over burden comprising of fertile soil and laterite which was mine earlier . Laterite is send to the bottom level and above that a thin layer of soil is left on the top for plantation activities. Reservoirs and sumps are made in the reclaimed area in order to collect the water and prevent the land degradation by soil erosion

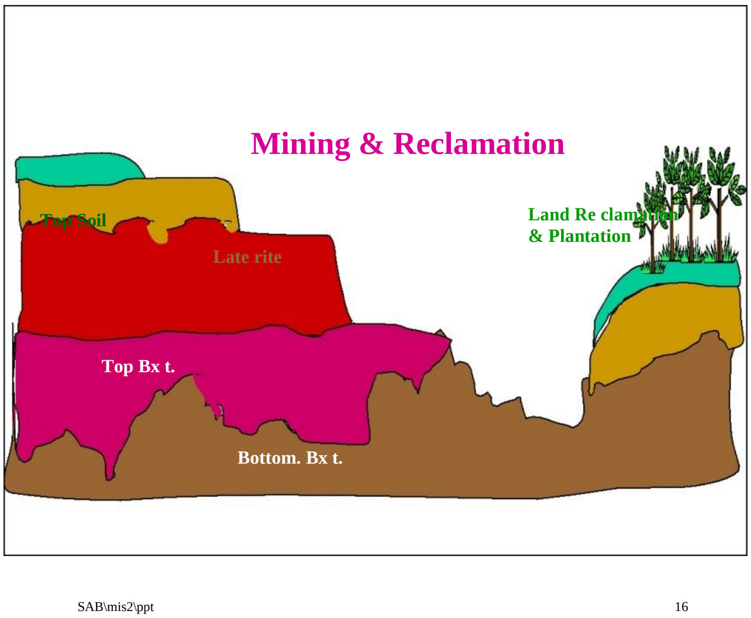


Fig 5.1.1 Technique for reclamation of mined area of the mine

5.1.3 <u>Drilling and blasting operation</u>

The current exercise of Drilling and Blasting has been adopted from the beginning of the mine to optimize the use of explosive energy. Mainly A.N.F.O is used explosive in non-rainy days Also, ANFO is mixed by imported Mingling and delivering truck of very high capacity. Cartridge and/or Cast booster is largely used as booster. Where the dry holes are present there cartridge column charge is used with cartridge booster. Explosives are stored in safe places as per regulation and they are properly handled.

5.1.2 **Drawbacks of using drilling blasting technique**

- As, it is naxal prone area also from the experience of past attack it is to be stored with proper security and the explosives attracts them.
- The desired size ore is not found because of variation in the sizes of ore after blasting.
- Since the mine is located on hilly region and valley is nearby with the short amount of vibration it can pose a serious threat
- Since the area is located in forest region it can have adverse effect on wildlife habitat.
- Lot of dust as well as high level of noise is produced which is injurious for the men.
- In the process of blasting results in back interruption and projections which are unsafe for equipment operating there.
- For the shifting of men and machineries a lot of idle time is inevitable.
- The rock left after blasting needs to be cleaned at the face before loading which further rises the idle time allotted for the equipment.
- Letdown of blasting, misfire directly effect to the production as well as productivity.
- It is difficult for the operator to differentiate between ore and waste
- In adverse weather condition such as in rain and dense fog is not possible for the safety point of view.
- Bucket fill factor for the dozing material is more as compared to the blasted material.
- Heavy amount of power is wasted to load the blasted material.
- It is not easy to distinguish between ore and overburden so blasting will mix both the materials.

5.1.5 <u>A lot of prior studies have been done before employing ripper dozer in Panchpatmali bauxite mines which are stated below</u>

1) Determination of seismic wave velocity in laterite bauxite and khondalite done by N.G.R.I Hyderabad (Field as well as laboratory)

No of species	**Laterite**	**bauxite**	**khondalite**
80%	1100m/s	1300m/s	1400m/s
90%	1500m/s	1500m/s	1500m/s
95%	1800m/s	1700m/s	1700m/s
100%	2600m/s	2200m/s	1900m/s

Table 5.1.1 Findings from the test carried out by N.G.R.I Hyderabad

Table 5.1.2: Study of physico-mechanical properties of both laterite and bauxite by I.I.T Kharagpur.

Rock property	laterite	Vesicular bauxite	Massive bauxite	Soft bauxite	khondalite
Dry density (kg/m^3)	2.0	1.85	2.1	1.8	1.9
Moisture Content (%)	2.0	2.2	2.5	2.5	7.0
Compressive Strength (kg/cm^2)	140+/- 70	92+/- 31	144+/- 87	85+/- 35	32+/- 36
Tensile strength(kg/cm^2)	26+/_ 13	18+/- 4	25+/- 6	16+/- 3	15+/- 4

This test clearly indicated that the ore present at Panchpatmali mine is very liable for ripping.

5.1.6Manufacturers and the population of dozer used in Panchpatmali bauxite mines are given below:

1) BEML D-355---------------------------------3Numbers

2) BEML D-475---------------------------------1Number

3) Komatsu D-375----------------------------2Numbers

4) Komatsu D-475-----------------------------2Numbers

Figure 5.1.2 Komatsu D-475 working the mine

There all specifications have been given under the table of specifications for all the ripper and dozers.

5.1.7 Comparison of drilling and blasting with ripping on the basis of the cost

5.1.7.1 Drilling and blasting cost for per tonne extraction

Average drilling operation in a day --560m.So as we had 2 working shifts = 280m per shift, 3 drilling machines were used and for operating them three operators were employed, actual working hour in a shift = 4 hrs., interest for one drill machine = Rs. 4417.8469, Depreciation cost of machine=Rs. 6126.25 ,Rear and Management expenditure=Rs.5416.667.

Table 5.1.3 Calculation for expenditure for drilling per MT

Particulars	***UoM***				
Drilling per day	m	560			
particulars	***UoM***	***Quantity***	***Rate/unit***	***Value-Rs***	***Per unit***
Material cost	@2%			654	1.17
HSD	litre	1200	Rs45/lit	54000	96.42
Conversion cost					
Labour cost				9000	16.07
Depreciation				18379	32.82
R&M cost@10%				16250	29.02
ADMN Overhead				9168	16.37
Interest				13254	23.67
Total cost/m					**215.54**

Table 5.1.4 Expenditure on the blasting operation for per tonne of the material

Particulars	***UoM***	***Quantity***	***Rate/unit***	***Value (Rs)***	***Per unit(Rs)***
Material generated	M	560			
	T	1200			
Material cost					
Explosive	kg	9000	32	288000	24
HSD for explosive Van	litre	60	45	2700	0.25
Conversion cost					
Labor cost				9000	0.75
Depreciation				4241	0.35
R&M @10%				3750	0.32
Admn OH@10%				25409	2.12
Interest				3059	5.46
Total cost					**33.90**

Explosive usage in a single hole------114 kg

Drilling expenditure of single hole -------------------Rs 1725

Material found after explosion -------------------------200 Tonnes

Drilling expenditure per MT-------------------------- Rs 8.65

Whole expenditure on Drilling & blasting per MT-----33.90+8.65= **Rs 42.55 per T**

Shovel is also introduced if operation for excavation and loading purpose.

Its operation and repairs costs = Rs. 12.42 per Tonne.

Total cost = 42.55 + 12.42= Rs. 54.97 per Tonne

5.1.7.2 Expenditure on ripper and dozer for extraction per T (tonne)

Material removed per day -7200Tonnes

Exact working hours in a day—8

Two dozers operating in one shift

Total Diesel usage -2000litre

Expenditure on labour Rs -6000 per day

Table 5.1.5 Total expenditure on ripping per T (tonne)

Particulars	**unit**	**quantity**			
Material generated	T	7200			
Particulars	**UoM**	**Quantity**	**Rate/unit**	**value**	**Per unit**
A) Material cost					
consumbles@2% of R&M				6545	.91
HSD	Litre	2000	Rs 45/lit	90000	12.5
B) Conversion cost					
Labourers cost				6000	.833
Depreciation				61263	8.51
Repair& maintenance cost @10% residual cost				32725	4.55
Admn.overhead@10%				22053	3.06
Interest on capital				44178	6.14
Total cost/per MT					36.503

For loading the material loader is used .So expenses on loader= Rs. 14.92 per Tonne.

Total expenditure on ripping and dozing operation = 36.503+14.92= 51.423 per Tonne.5.2

FIELD STUDY 2: TALABIRA- 1 COAL MINE, OCP, HINDALCO

5.2.1 Introduction:

Talabira-1 mine is the first blast free coal mine in India. It is also the first mine of ODISHA state to have ripper dozer and surface miner working on the same mine. It is located in the SAMBHALPUR district of ODISHA. H.I.N.D.A.L.C.O owns its whole governing authority. Mainly the extraction is done by the surface miner and ripper and dozer. As the surface miner is present for the operation no coal handling plant is required. Loading and transporting of coal is done on contractual basis.

5.2.2 Geological condition of Talabira-1

It is situated on eastern lb valley coalfield. Total constituting area is 2.60 sq. km and the permissible lease given to H.I.N.D.A.L.C.O is 1.70 sq. km the residual goes to the forest department and department of water resources. Location of the mine is adjacent to Hirakud dam. It is affected mainly by three main faults (N-S, NW-SE, NE-SW) in which the NE-SW fault separates it from Rampur Colliery. Deposit belongs to Karharbari and Barakar foundations. The three connected ruptures of Ib seam signify the Karharbari formation. Contrary to that the Barakar creation on the other hand, contains five connected horizons constituting the top and four ruptures of Rampur bottom seam. The top seam of the Rampur is the earliest and the widest seam.

Table 5.2.1 <u>Geological condition of Talabira-1 block (*H.I.N.D.A.L.C.O, 2011*)</u>

Name Given to the seam	Variation in the depth	Parting in meters	Thickness in meters	Direction of dip	Rate of dip	Nature of overburden
Rampur top	8-54			NW-SE	5^{o} to 10^{o}	Top soil/ boulder clay
Rampur bottom-III	6-60	2-5.32	0.44-2.76	NW-SE	5^{o} to 10^{o}	Sandstone & shale
Rampur bottom-II	6-66	071-6.15	0.44-3.01	NW-SE	5^{o} to 10^{o}	Sandstone & shale
Rampur bottom-I	6-74	0.3-3.42	0.24-5.57	NW-SE	5^{o} to 10^{o}	Sandstone & shale
IB-III	18.37-82.71	2.34	0.4-3.83	NW-SE	5^{o} to 10^{o}	Sandstone & shale
IB-II	32-92.00	2.66	0.14-2.0	NW-SE	5^{o} to 10^{o}	Sandstone & shale
IB-I	36-08		0.25-2.54	NW-SE	5^{o} to 10^{o}	Sandstone & shale

5.2.3 **Important features of Talabira-1 Open Cast Mine:**

- Lease area for mining : 170.305 Hectare
- Area having coal deposit : 89 Hectare
- on-going working area for mining : 55 Hectare
- Total reserve for extraction of coal : 23.50 MT (million tonnes)
- Grade of coal : G & F
- Total working seams : 7 numbers
- Utilisation of coal : For generation of power
- Average. stripping ratio of mine : 1.09 m^3/tonne
- Dip of the seam : 5^o-10^o
- O.M.S : 31.56 tonne
- Thickness range for the seam : 0.7- 44.69m

5.2.4**Choice and usage of Ripper dozer in Talabira-1:**

As Hirakud dam is nearby so according to D.G.M.S regulation blast free mining method is being adopted Ripper dozer are selected on the basis of seismic wave analysis .With the help of ripper and dozer overburden is removed and with the help of surface miner coal is removed. For loading of overburden loaders are used whereas for loading of coal dumpers are used. Two rippers (KOMATSU D-475A) are used for ripping of the overburden. There specification is given in the above table for the specifications.

5.2.5 <u>Comparison of ripping cost with drilling and blasting cost</u>

Table 5.2.2 **<u>Cost of ripping for per tonne of overburden.</u>**

Particulars	**unit**	**quantity**			
Material generated	T	7800			
Particulars	**UoM**	**Quantity**	**Rate/unit**	**value**	**Per Unit**
A) Material cost					
consumbles@2% of R&M				6500	.833
HSD	Litre	2160	Rs 45/lit	97200	12.46
B) Conversion cost					
Labourer cost				6000	.769
Depreciation				61260	7.854
Repair& maintenance cost @10% residual cost				32500	4.167
Admn.overhead@10%				22000	2.82
Interest on capital				44178	5.66
Total cost per MT					**34.563**

Since loader is required for loading so for having dozer and its maintenance cost = Rs.14.92

So total cost of ripping comes to be = Rs.49.483 per T

Cost of drilling and blasting for per tonne of overburden:

Drilling cost (per meter) = Rs.215.54

Drill hole diameter = 150mm

Depth of the hole = 7.8m

Drilling cost per hole = Rs.1681

Total material produced = 344 Tonne

Cost of drill per Tonne = Rs. 4.88

Cost of blast = Rs.38.63 per Tonne

Cost of labour = Rs. 0.75 per Tonne

Cost of depreciation = Rs.0.35 per Tonne

Cost of repair and maintenance= Rs. 0.32 per Tonne

Cost of overhead administration = Rs.2.12 per Tonne

Interest = Rs.5.46

Total blasting cost = Rs.47.63 per Tonne

Total expenditure on shovel = Rs. 12.42 per Tonne

.**Cost for the total drilling and blasting = Rs 64.94 per Tonne**

Clearly we can observe that ripping and dozing is more economical.

CHAPTER 06

RECENT DEVELOPMENTS IN THE FIELD OF RIPPER DOZER

6.1 Remote operation of ripper and dozer: (*Remote control technologies Pv.t Ltd, Australia*)

For the remotization of the ripper and dozer only Remote Control Technologies is responsible. This company designed various models for Caterpillar, i.e. D5N, D8T, D9H, D10, D10N, D10R, D11N, D11R Series 1, 2, 3, KOMATSU D475, D572-A2, D575A,D575A-3 &D275AX.. RCT is the first one to install remote control for a dozer CAT D11NinPNG in 1989. In 2006 RCT was the first in the world to remote control a CAT D8T dozer.

6.1.1 Following are the advantages of remote control operation:

- Prevents repetitive stress injuries.
- Maximization of machine utilization.
- Greater overall operator vision.
- Improved ergonomic working condition for operator.
- Less idle time between production cycles.
- More control of critical machine tolerances.
- Hazardous machine tasks can be accomplished safely.

6.2 Mine APS Dozer

It is the real example for the introduction of modern technology. It is a GPS+GLONASS appliance supervision solution for dozers, allowing quicker, safer and additional productive operation. Great accuracy GPS+GLONASS supervision allows accurate dozing to plan without the need for rechecking or fixing.

6.2.1 Features:

- Accurately report machine position in 3D relative to digital design.
- Open system technologies include MS Windows, SQl, XML, NMEA, Share point services.
- Compact and flexible GPS+GLONASS receivers to balance investment and application.
- Easy to use touch screen operator interface.
- Operator can choose to work to design surface or offsets.
- Support multiple user selectable surfaces in a single file.
- Onboard system diagnostics.
- Fixed hazard and mobile equipment proximity warnings.
- Optional ripper sensor.
- Optional blade guidance sensor.
- Open communications interface compatible with 3G cellular, 802.11x, mesh and other communication systems.
- Off board and onboard production reporting options by machine, area, group or operator including: volumes, push distances, cycles, re handle, idle vs. push vs. ripping, delays, export DTM of ‘as built’ surface.

6.2.2 <u>BENEFITS OF THE SYSTEM:</u>

- Selective mining is possible leading to improved grades.
- Improved safety through fixed hazard and proximity warnings.
- Improved efficiency and reduced errors.
- Achieves results faster with fewer passes.
- Reduce rework caused by over or under cutting or filling.
- Significantly reduce dependence on survey and grade checking.
- Machine based production reporting removes errors and improves timeless and accuracy of management information.

CHAPTER 07

CONCLUSION

- With a large amount of usage of reformed technology ripping has become important operation than drilling and blasting.
- Major demerit is that it is not applicable for very hard rocks. So it may be associated with drilling and blasting for a better solution.
- From the above findings we can conclude that it is an economical cheaper and safe operation.
- It can be solution as blast free mining system.
- Ripping do not have any adverse effect on environment hence we can protect the environment and wildlife habitat.
- The ores or overburden extracted has uniform size so there is no need for secondary operations such as secondary blasting.
- With the more advancement in techniques and machinery it can come as final solution for drilling and blasting.

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